

## CHAPTER 5

### FUEL OIL SYSTEMS

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#### 5-1. Simple fuel oil system

In a simple fuel oil system there is only one device using fuel oil and the fuel oil tank is located close to the equipment being served which allows the tank to supply fuel oil to the equipment and receive returned oil without an intermediate service tank.

*a. Storage.* The fuel oil tank is a double wall, horizontal, cylindrical tank and could be located either above or below ground. Fuel oil is drawn out from the top of the tank by the fuel oil pump suction line. A top discharge is best for horizontal tanks. The suction line can be installed some distance from the bottom of the tank to prevent water separating from the fuel oil in the tank from entering the supply system. Tanks typically have a high suction and a low suction line. Normal operation is through the low suction line. If an accumulation of water enters the low suction line, facility operation can be switched to the high suction line until the accumulated water is removed. Once the water is removed, it is important to switch back to the low suction line. Fuel oil storage tank fill and return lines typically terminate in trap sections. In the event the tank is drawn down past these lines, the trap section minimizes the likelihood that combustible vapors can exit the tank and create a hazard within the facility. Also, the fuel oil supply piping has an expansion chamber which prevents expanding oil from leaking through joints and shaft seals or causing physical damage to the system.

*b. Fuel delivery.* The fuel oil used in the facility may require heating in cold weather to reduce the fuel oil viscosity into the pumpable range. The heating is provided by a steam or hot water coil surrounded by a box-like structure to form a suction heater. Fuel oil is drawn from the tank through a suction strainer by a fuel oil pump. The fuel oil is pumped through a coalescing filter to remove water and through an oil heater to reduce the fuel oil viscosity into the atomizing range. Fuel oil not used by the equipment is returned to the fuel oil storage tank. If the amount of hot oil returned is likely to cause the storage tank to fill with oil vapor, the return oil would be cooled to below the flash point by a fuel oil cooler before being discharged into the tank.

*c. Fuel selection.* Lighter weight fuel oils such as FS2, DF2, DFA, and JP fuels have a much lower viscosity, which allows them to flow more easily during cold weather. Unless the outside air temperature is extremely cold, pre-heaters are not normally required when using these fuels. Heavier oils such as FS4 (and especially FS6), due to their high paraffin content, do require the heaters in cold weather. The need for preheating should be considered by the facility in specifying the fuel requirements for new or replacement equipment such as boilers. The heavier fuels have a higher BTU content and are usually less expensive. However, the cost of preheating the fuel can easily make the lower viscosity fuels cheaper in the long run. Also, the higher viscosity fuels often have a higher sulfur content, which may present an air quality problem in certain areas

#### 5-2. Complex fuel oil system

A more complex fuel oil system is shown on figure 5-1. The complex fuel oil supply system is serving a diesel engine unit that can run on less costly heavy fuel oil (No. 5 or No. 6), but requires a more expensive light fuel oil (No. 1-D, No. 2-D, No. 1, or No. 2) for starting the engine. In this instance, the

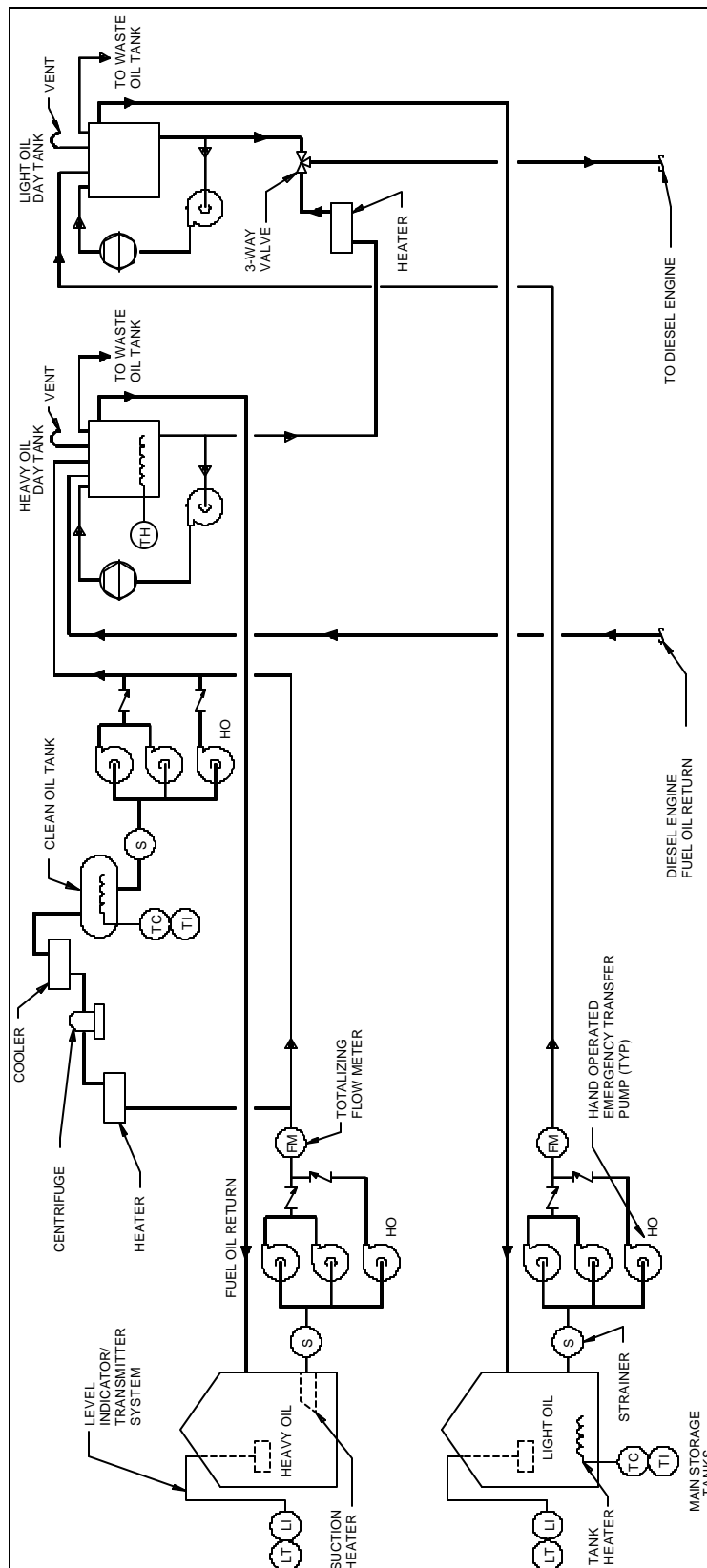


Figure 5-1. Complex fuel oil system - supply

quantity of fuel oil used by the facility requires a tank farm some distance from the point of use and the quality of the heavy oil requires on-site conditioning before use. Note that critical fuel oil transfer pumps have installed spares, and critical transfer points have hand-operated pumps in parallel with the motor-operated pumps to allow a minimum level of fuel transfer in the event of unplanned electric service supply outages.

*a. Storage.* The fuel oil storage tanks are equipped with level indicators and level transmitters. The heavy oil tank uses a suction heater to adjust oil viscosity while the light oil tank uses a whole tank heating system to maintain the oil above the pour point temperature. All aboveground piping and oil transfer equipment are heat-traced.

*b. Conditioning.* Because of the water and sediment in the as-delivered heavy fuel oil, the heavy fuel oil requires conditioning before final use. In the example system on figure 5-1, fuel oil conditioning is accomplished using a centrifuge. The heavy fuel oil feed to the centrifuge must be further heated to reduce the viscosity into the atomizing range. The fuel oil discharged from the centrifuge is passed through a fuel oil cooler to eliminate flash point problems before being discharged into a clean oil storage tank that is heated to keep the fuel oil viscosity at a pumpable level.

*c. Fuel delivery.* Heavy fuel oil is transferred from the clean oil tank to a heavy oil day tank at each diesel engine. Light fuel oil is transferred from the light oil main storage tank to the light oil day tank at each diesel engine. Both day tanks are equipped with systems to circulate the fuel oil through coalescing filters to remove any water in the fuel oil. The heavy fuel oil day tank is equipped with a heater to maintain the oil viscosity at a point that will flow to the engine. Additional heating of the heavy fuel oil is required to reduce the oil viscosity into the atomizing range as the oil is supplied to the engine.

(1) The heavy fuel oil and light fuel oil are supplied to the engine through a three-way valve. On initial starting, the three-way valve is positioned to use light fuel oil. Light fuel oil is used until the engine reaches operating speed and temperatures. Once the engine operation is stabilized, the three-way valve is positioned to supply heavy fuel oil to the engine. During a normal shutdown, the three-way valve is positioned to supply light fuel oil to the engine to purge the heavy oil from the engine fuel system before engine operation is terminated.

(2) The fuel oil day tanks are positioned above the engine so fuel oil is supplied by gravity to the inlet of the engine-driven fuel oil pump. Some installations may require self-priming, engine-driven fuel oil pumps to draw fuel into the pump, or there may be an additional set of pumps between the day tanks and the engine-driven pump to get the fuel oil to the engine-driven pump inlet. Whenever the engine fuel oil system has been drained, many engine designs require that the system be filled with fuel oil before a normal start is attempted and a hand-operated pump is provided for this purpose. Fuel oil supplied to the engine-driven fuel oil pump passes through a shutoff valve and a duplex strainer. The engine-driven fuel oil pump discharges through a duplex fuel oil filter to the engine fuel injection system. Excess fuel oil passes through an air-cooled fuel oil cooler, a check valve, and an engine fuel oil system isolation valve, and is returned to the heavy fuel oil day tank.

### **5-3. Fuel oil system major components**

The fuel oil system is comprised of the following major components.

*a. Fuel oil pipeline flowmeter.* The fuel oil pipeline flowmeter is a rotary displacement type flowmeter used to measure fuel oil quantities for accounting purposes.

*b. Fuel oil storage tank heaters.* Fuel oil storage tank heaters for outdoor aboveground tanks will vary in type as follows.

(1) Low watt density electric heating elements are arranged on the bottom of the fuel oil storage tank. Sometimes they are also designed to be flange-mounted through the side of the tank.

(2) Hot water is circulated through heat exchanger tubes that are immersed in the fuel oil. In most cases, the tube assembly is mounted through the side of the tank on a flanged nozzle.

(3) The heating of the fuel oil storage tank is similar to that used for a hot water system; only the heating medium is steam.

(4) A suction heater is designed to be mounted on or in the fuel oil storage tank suction nozzle that heats the fuel as it is drawn from the tank.

*c. Fuel oil supply heat tracing.* Heat tracing is installed on lines to maintain the temperature of the fuel oil in the lines to prevent viscosity or pour point problems. Heat-traced lines and equipment are generally insulated. Mechanical heat tracing is generally a tube clamped and thermally bonded to the outside of the fuel oil pipe. Steam or hot water is passed through the tubing. Electric heat tracing is by means of flexible resistance heaters that can be wrapped around the pipe.

*d. Strainers.* Strainers are used to remove coarse particulate matter that may damage rotating equipment. Typical strainers use a screen-like mesh or perforated metal element (Y type and basket type strainers) or closely spaced parallel rows of sharp-edged metal bar elements (metal-edge type strainer). They may include magnetic elements for removal of iron and steel particles. Duplex strainers have two strainer elements of equal capacity connected in parallel by a valve assembly that allows the process stream to be diverted from one strainer element to the other without interrupting flow. Duplex units are used in systems that cannot be conveniently shut down for maintenance.

*e. Fuel oil filters.* Fuel oil is filtered to remove particulate matter and to remove water. Filters designed to remove water from fuel oil are known as coalescing filters.

(1) Particulate filters are used to remove fine particulate from fuel oils. Filters in fuel oil systems are generally made up in cylindrically shaped "cartridges" or elements of a size convenient for handling. Unless the filter element is of the metallic, permanent type that can be cleaned, filter elements are typically used once and then discarded. In locations where the fuel oil system can be shut down for maintenance, single-element filter units are generally installed. In critical services, duplex filter units designed to allow switching from one bank of filter elements to another without interrupting the flow of fuel oil are generally used.

(2) Fuel oil systems typically use coalescing filters to remove water from the fuel oil. Coalescing filters are also extremely efficient particulate filters.

*f. Centrifuges.* The fuel oil conditioning system centrifuge is utilized for purification (separation of liquids) and clarification (removal of solids). This unit is generally a high-speed centrifuge with a self-cleaning bowl.

*g. Control valves.* Control valves are installed in the fuel oil supply lines inlet to day tanks. The valves automatically open when the fuel oil in their respective day tank falls to a preset level. When the

valve opens, fuel oil flows into the day tank. When the level in the tank reaches another preset (higher) level, the valves automatically close, stopping the flow of fuel. The operation of the control valves is controlled by level switches.

*h. Fuel oil day tanks.* Fuel oil day tanks are usually located at an elevation above the engines. The day tanks are generally a cylindrical type tank with a capacity for storing a four- to eight-hour supply of fuel oil. The tank has a manhole, a supply inlet connection, a vent connection, an overflow connection, a fuel return connection, a fuel supply outlet connection, and two connections for the level controller and indicator.

*i. Waste oil storage tank.* The waste oil storage tank is generally a cylindrical type and will be double-walled if located underground. The tank will have nozzles for vent, tank pump-out, fill, and level monitoring. Underground tanks may have a leak detection system, level indication, and overfill alarms.

*j. Pumps.* Various types of pumps are utilized in fuel oil systems.

(1) The pumps used to transfer fuel oil throughout the facility may vary from installation to installation. The types of pumps likely to be found in fuel oil service are as follows.

(a) Centrifugal pumps, horizontal, are preferred for pumping from aboveground tanks with continuously flooded pump suction when viscosity considerations or the pressure drop of filter devices following the pump are not a concern.

(b) Vertical centrifugal pumps may be used, but are not preferred, for pumping from underground tanks (or from horizontal, cylindrical tanks). These pumps may have multiple stages.

(c) Turbine pumps, vertical, are preferred for pumping from underground tanks.

(d) Positive displacement pumps are used where a relatively constant flow over a range of system pressures may be encountered, or when the viscosity of the fluid or the oil filtering system components require relatively high pump discharge pressures. In installations or service where a flooded pump suction line cannot be ensured, the pump should be of the self-priming type. Positive displacement pumps are common in fuel oil service. The three most common are rotary lobe, sliding vane, and gear type pumps.

(2) Fuel oil transfer pumps are generally rotary positive displacement type pumps equipped with integral pressure relief valves. The pumps are typically controlled by a locally mounted pump control panel.

(3) Hand-operated pumps are recommended for limited fuel oil transfer during unexpected outages of the electric motor-driven transfer pumps when the arrangement of the facility does not allow filling service tanks by gravity.

(4) The engine fuel oil pump supplies fuel oil to the engine fuel injector system at the required pressure for proper atomization of the fuel oil when the engine is operating. The fuel oil pump is usually mounted on the engine and is gear-driven from the engine. The engine-driven fuel oil pump is generally a positive displacement pump that is usually of the rotary lobe or gear type. Depending on the equipment manufacturer, the pump may be equipped with an internal pressure relief device that will return oil to the inlet side of the pump in the event the discharge of the pump is blocked.

(5) The engine priming pump is used to fill the fuel oil system any time the fuel system has been drained or opened for maintenance, or the engine has been out of service for an extended period of time. The priming pump is generally a hand-operated pump of the positive displacement type.

*k. Fuel oil.* The manufacturer's recommended fuels should only be used as specified in the equipment literature. In general, most fuel oils will be supplied in accordance with Federal Specification A-A-52557, Fuel Oil, Diesel; For Posts, Camps, and Stations; or Military Specification MIL-F-16884J, Fuel, Naval Distillate. Dirty fuels or fuels not meeting manufacturer's minimum specifications will adversely affect combustion, filter life, injection system performance, service life, and ability to start. They will also affect service life of valves, turbine blades, pistons, rings, liners, and bearings.

(1) A supplier should provide certified documentation prior to or with the fuel oil delivery, verifying that the oil has been tested by a certified laboratory and meets the specifications for the fuel oil used by the facility. If documentation is not provided for the fuel oil, the facility should sample and analyze the fuel oil prior to use. The facility should take samples of all fuel oil delivered to the facility and retain the samples until that lot of fuel oil is used. Even if certified test reports are provided by the supplier, the facility should periodically have independent analyses performed to ensure compliance with purchase order or contract requirements. A simple delivery test is to visually check the quality of fuel oil delivered by collecting a sample of every fuel oil delivery in a clear, clean, dry, glass bottle. As each sample is taken, tightly cap the bottle and identify the bottle with information, such as date, supplier identification, purchase order, specification, etc. Allow the sample to settle for at least 8 hours, and compare it with a similar bottle containing a fuel oil known to be of acceptable quality. A cloudy appearance suggests that fine droplets of water are entrained in the fuel which, in time, will settle to the bottom of the sample. Any contamination in gasoline or kerosene (lighter fractions) will float and collect at the top of the bottle. Contaminants, such as pipe scale or other foreign solids, will settle and collect at the bottom of the sample. If doubt exists as to the quality or identity of the fuel oil after the visual examination, the sample should be laboratory-analyzed for compliance with the specification.

(2) A periodic inspection of stored fuel and fuel systems is important to ensure reliable engine performance. Many engine failures are caused by fuel contamination. The following in-service testing suggestions are given for preventing and/or detecting post delivery fuel contamination.

(a) Monitor storage tanks (main tanks, intermediate tanks, day tanks, etc.) for accumulations of water, and remove water frequently.

(b) Keep storage tanks as full as possible (especially in cold weather).

(c) Do not mix different grades of fuel oil.

(d) Use oldest fuel oil inventory first. Long-term storage may result in the formation of sludge or the growth of soluble and insoluble bacteria that can clog fuel filters and injectors. If sludge in filters is noticed, switch to a different fuel oil supply and have suspect supply tested. If suspect supply is found to be unacceptable, discard unacceptable fuel oil.

(e) When strainers are cleaned or filters are changed, carefully inspect elements for unusual amounts of rust, scale, or sediment. If unusual amounts are observed, inspect fuel oil storage and delivery system upstream of the strainer or filter to determine and correct the cause of the contamination.